TIDAL STREAM INDUSTRY ENERGISER

EUROPEAN UNION
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TIGER
Tidal Stream Technology and Project Development (WP T1) Final Lessons Learnt

V2

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Disclaimer

Contents

1 Introduction

1.1 The TIGER project

The TIGER project was launched in October 2019 and was completed in July 2023. The TIGER project has built cross-border partnerships to develop new tidal stream energy (TSE) technologies, test and demonstrate them at a number of project locations (mainly around the Channel region), and use the learning from these developments to make a stronger case for cost-effective TSE deployments as part of the France/UK energy mix.

The aims of TIGER included the leveraging in of other funding for the actual installation of future TSE arrays at TIGER project locations, which is as important as obtaining the necessary consents within TIGER, and this was supported by design work within TIGER.

The project delivered new designs for turbines, with improved performance and lower cost, as well as for associated infrastructure and ancillary equipment. TIGER has demonstrated that TSE is a maturing industry, capable of achieving an accelerated cost reduction pathway. The project has positioned the Channel region at the heart of the sector by:

- addressing technology challenges;
- building the supply chain;
- switching on new sites; and
- installing new turbines.

For more details of the TIGER project, see: https://interregtiger.com.

1.2 Work package T1 – project and technology development, and turbine and associated infrastructure deployment

Work package T1 focussed on:

- Obtaining the necessary consents and licences for potential future TSE projects, either for completely new sites or for sites where a previous consent and/or licence needed updating (e.g., to allow the application of different technologies or project scale or approaches):
    - Updated consents/licences for two sites at Raz Blanchard, France, with project partners (a) Normandie Hydroliennes (formed of project and technology developer SIMEC Atlantis Energy (SAE) [this partner became Proteus Marine Renewables (PMR)], AD Normandie and EFINOR) and (b) project and technology developer HydroQuest.

  - Updated consent/licence at Perpetuus Tidal Energy Centre (PTEC, 2.5km south of Isle of Wight), England, with project partner European Marine Energy Centre (test and demonstration centre, EMEC).
  - Updated consent/licence at Paimpol Bréhat (test and demonstration centre), Brittany, France, with project partners Electricité de France (EDF) and SEENEOH (test and demonstration centre).
  - Updated consent/licence at Ramsey Sound, Wales, with project partner Cambrian Offshore South West (project developer).
  - New consent/licence at Gulf of Morbihan, France, with project partner Morbihan Hydro Energies (formed of project developer 56 Energies and project and technology developer Sabella).
  - New consent/licence at Yarmouth, Isle of Wight, England, with project partner QED Naval (project and technology developer).
- Project development activities, including one or more of financing, design, fabrication, onshore testing, offshore installation, and operation of TSE turbines. This included:
  - Offshore installation and operation of turbines within the TIGER project timescales at Paimpol Bréhat (HydroQuest); Ushant Island, France (Sabella); Langstone, England (QED Naval); and MeyGen, Scotland (SAE).
  - Design activities for the projects planned to be installed after TIGER at Raz Blanchard (up to 30MW), PTEC (up to 30MW), and Morbihan (0.5MW).
  - Fabrication and onshore testing of multiple TSE turbine components.
- Industry learning and dissemination, including this lessons learnt report and the "Guidelines for development of tidal energy projects" – one on consenting, and the other on site selection and development - as well as many other reports and academic papers resulting from the TIGER project (see Section 2 for a summary): https://interregtiger.com/resources/.

1.3 This report

The aim of this report is to disseminate the lessons learnt from the activities within work package T1. This V2 report is an update to the V1 report issued in May 2022, and also includes the lessons from the first half of the TIGER project (which were detailed in the May 2022 report).

The information within this report was compiled from information held by, and internal discussions between, ORE Catapult, Baldock Energy Limited, and T1 project partners.

The value to the wider industry of any lessons learnt report is often in the detail of the experiences, rather than in any overall generic conclusions which may appear abstract or obvious. This report therefore includes a number of the detailed experiences, to allow the wider industry to draw parallels between the experiences of TIGER and their own projects, even if wider industry participants face somewhat different circumstances. The project partners specific to any lessons learnt are not named in this report, to protect confidentiality, and in many cases the experiences were common to multiple partners. Likewise, to protect confidentiality, the full details of the experiences are not provided. It is noted that project partners' experiences and the stated lessons learnt are not necessarily completely new to the sector - such experiences and lessons are included to remind readers of them and to highlight their importance.

Some of the experiences within TIGER form intellectual property that has commercial value to TIGER project partners and/or their suppliers. The sharing of lessons learnt has to balance the benefits of building a strong TSE industry with protecting the interests of TIGER project partners and/or suppliers and their investors. The internal process followed in developing this report has been open; however, there are some experiences and lessons discussed internally within TIGER that are not included in this report.

1.4 T1 project partners

Details of all the TIGER project partners can be found here: https://interregtiger.com/about-tiger/project-partners/.

Work package T1 project partners are those TIGER project partners with project and technology development and deployment activities: Cambrian Offshore South West, EDF, EMEC, HydroQuest, Minesto, Morbihan Hydro Energies, Normandie Hydroliennes, QED Naval, and SEENEOH. ORE Catapult is the lead partner for TIGER and hence involved in work package T1 as well as all other work packages.

European Regional Development Fund (ERDF)

The Interreg VA France (Channel) England programme is an EU programme that funds projects that benefit the Channel area in the south of the UK and the north of France, using ERDF funds. The programme provides funding for projects where partners work together to find solutions to common challenges in the Channel area.

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2 Lessons Learnt

As noted in Section 1.2, there are a large number of documents on the TIGER website at: https://interregtiger.com/resources/. As well as the "Guidelines for development of tidal energy projects" referred to in Section 1.2 (first two links below), there are many other documents which contain valuable information developed during TIGER. Documents referred to in this report, and other key documents of general interest, include:

- Consenting: https://interregtiger.com/download/tiger-report-consenting-in-france-and-the-united-kingdom/
- Site development: https://interregtiger.com/download/tiger-report-guidelines-for-development-of-tidal-energy-projects/
- Site development case study (UK) at PTEC: https://interregtiger.com/download/tiger-lessons-learned-from-developing-tidal-sites-in-the-uk-channel/
- Data collection and survey: https://interregtiger.com/download/tiger-data-collection-and-survey-best-practice-report-2022/
- Data collection and survey case study (UK) at MeyGen (novel resource analysis method and measurements, and turbulence and wake measurements): https://interregtiger.com/download/technical-report-on-high-fidelity-flow-data-field-work-and-analysis-including-vessel-based-flow-measurements-and-turbulence-measurements-at-meygen/
- ADCP data collection lessons learnt: https://interregtiger.com/download/tiger-tidal-test-procedure-reports/?wpdmdl=6239&ind=1690366406406
- Value in UK energy system: https://interregtiger.com/download/tiger-report-role-and-value-of-tidal-stream-generation-in-the-future-uk-energy-system/
- Cost reduction pathway: https://interregtiger.com/download/tiger-report-cost-reduction-pathway/
- Volume manufacturing roadmap: https://interregtiger.com/download/tiger-report-tidal-stream-volume-manufacturing-roadmap/
- Insurance: https://interregtiger.com/download/tiger-report-the-ocean-energy-accelerator/

There are also a number of other websites which have developed and/or compiled very significant repositories of TSE industry knowledge. These include:

- Tethys: https://tethys.pnnl.gov/ (general), https://tethys.pnnl.gov/knowledge-base-marine-energy (environmental effects), https://tethys.pnnl.gov/monitoring-datasets-discoverability-matrix (interactive tool on environmental effects), https://tethys.pnnl.gov/databases (external databases, including an ability to search for UK and French databases).
- PRIMRE (Knowledge Hubs): https://openei.org/wiki/PRIMRE/Knowledge_Hubs

2.1 Collaboration

- It may be important for the lead project partner to promote collaboration and lead difficult discussions between other partners even where those partners are naturally required to collaborate on the project to achieve their project objectives. Project partners should request assistance from the lead project partner where necessary.

- Collaboration between partners, including between project developers or technology developers that are (to some extent) in competition, and between partners based in different countries (UK/FR), is possible. This can help reduce project timescales and costs, as well as promote a better general understanding of the sector with stakeholders and regulators. However, collaboration does not happen naturally and needs promotion by the project funder and/or lead partner as discussed above. Collaboration is much harder if there are frequent staff changes at any organisation that needs to collaborate with another.

- Legal agreements always take significant time to agree, particularly where the partners operate in different languages.

  Treating such items as a mini-project in themselves and using standard project management techniques such as setting out the required activities and milestones with deadlines may help avoid such agreements taking significantly longer than expected.

- Lead partners should outline the requirements of the project (including information provision) more clearly at the application stage.

- All parties need to be clear on what commitments universities can make, when these commitments can be made, and for how long, given the different funding models.

2.2 Consents & licences

- Strong engagement with the relevant regulators and associated public sector stakeholders to understand the current consents and licencing approach, and build the case for the project, is a prerequisite to success – especially for particularly environmentally sensitive sites and/or sites where there may be significant local opposition (which also needs to be addressed via local stakeholder engagement).

- The “Guidelines for development of tidal energy projects” at https://interregtiger.com/download/tiger-report-consenting-in-france-and-the-united-kingdom/ provide a useful overview of the consents and licences process in the UK and France.

whilst https://www.etipocean.eu/events/navigate-through-permitting-in-the-uk-and-france/ presents a useful summary of this information.

There is further UK information in the case study in the T1.4.5 “Lessons learned from developing tidal sites” report at: https://interregtiger.com/download/tiger-lessons-learned-from-developing-tidal-sites-in-the-uk-channel/.

As noted in the introduction to Section 2, Tethys in particular has a very significant body of information relevant to the environmental aspects of consents.

- Ensure historical changes in regulations, processes and stakeholders are understood when working on sites with existing consents.
    - Previously accepted consents and licencing approaches may change over time.
    - Grid capacity availability changes all the time.
    - Previous data (e.g., environmental baselines) may not be re-useable if too old or if it does not meet latest requirements.

- There have been relatively few TSE projects consented in France and future larger projects (e.g., developed via a tender process) are likely to follow a different consenting route from those developed to date.
    - Projects need to include significant contingency to allow for an extended consent approval period until more historical data is available.
    - Projects should agree up-front with the relevant regulators whether a ‘design envelope’ approach can be used, and more generally all the information and documentation required for all the various approval authorities and their approval steps.
    - Projects should provide as much detail on their project as early as possible in the consent process.
    - All reports/studies being submitted to the authorities (even if they were originally published in English) should be translated into French.
    - If possible, provide information from third parties rather than internal reports, and ideally from third parties that are recognised by the authorities (for example the French Institute for Corrosion).

- Particularly for environmentally sensitive sites, it may be better to plan for a worst-case consenting approach/regime than to have to switch the approach during the consent process (either due to regulatory requirements or changes in the project design envelope).

2.3 Design

- Keep subsystem design options open whilst significantly different concepts (especially those with significant impacts on/from other subsystems) are being explored. Explore challenging design options in parallel, as concepts that often appear simple in the early stage of design are later found to become more complex/costly/heavier with consequential knock-on impacts.

- Design processes should have an integrated mass and dimensions requirements and management approach from early concept design, which is linked to key logistical step changes in approach or cost (e.g., use of certain vessels).

- Using divers for inspection or intervention operations at depths > c. 10m, and especially at faster tidal sites, should generally be minimised for multiple reasons (e.g., inherent health and safety risks, short dive durations during slack water, impacts on weather windows if combined with other operations, etc.). If divers are to be used, detailed preparations for the work with the divers, using pictures of the operations, may assist. Having on-site live measurement of the tidal current velocity is also paramount.

- Similarly, if using ROVs (remotely operated vehicles), it is important not to overestimate the ROV capabilities with respect to tidal current velocities, and having on-site live measurement of the tidal current velocity is paramount. The timescales for ROV operations need to account for recommended wet testing.

- Inaccurate cost estimating at the concept and outline design stages may lead to later delays at the detailed design and/or procurement stage, and can be mitigated by more detailed engagement with others and/or third-party review and/or higher contingency budgets.

- Design of power systems equipment and automation equipment must often be prioritised in any R&D or delivery project due to the long equipment lead time. It may be necessary to purchase equipment ahead of design completion, which carries risk. Robust ways of mitigating these risks need to be well thought through at the start of a project. Suppliers must also be closely managed, but will prioritise renewable energy and innovative projects if good relationships with account managers are fostered.

- Although all aspects of a tidal turbine and its ancillary equipment need to be designed robustly for the expected forces, cable fastening in particular appears to need more attention in the design phase.

- Design of a pilot project needs to consider (later) build out of arrays. Turbines are designed for a c. 20-year life and are very difficult to move once deployed.

- Where possible, future turbine locations may be determined based on largely avoiding the expected wakes from pilot and future turbines, where the relevant wake length may be as high as c. 12-15 times the turbine diameter. The "T1.6.6 – MeyGen 2022 Field Work Analysis" report available at: https://interregtiger.com/download/technical-report-on-high-fidelity-flow-data-field-work-and-analysis-including-vessel-based-flow-measurements-and-turbulence-measurements-at-meygen/ contains further information on wake measurements undertaken in TIGER, from operational 18m diameter, 1.5MW, tidal turbines (see example above).

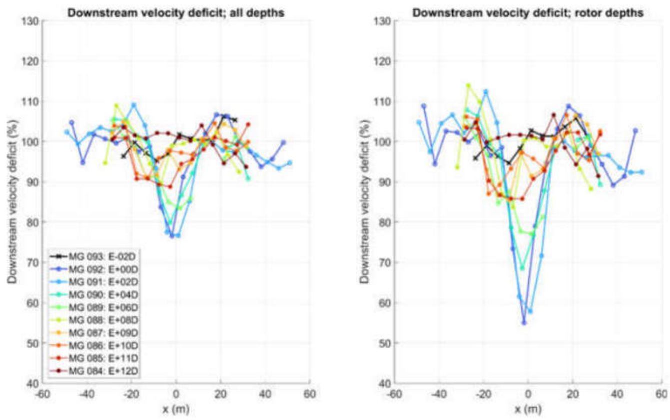


Figure 26 – Downstream velocity deficit, ebb direction (turbine on)

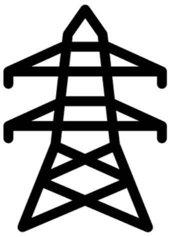
2.4 Grid connection

- The complexities associated with grid-connecting tidal arrays need due attention at the relevant points in the design process. Connecting arrays is significantly more complex than connecting single turbines and needs a different approach.

- Understanding how to achieve grid connection requirements needs an open two-way discussion between the project/technology developer and the grid connection provider. This may be more difficult and time consuming where the parties operate in different languages and/or where the technology developer is protective of their detailed technical information.

- Grid connection agreements may be delayed due to lack of understanding of the process and/or a lack of information available on the new generating asset(s).
  - Sometimes, more information than is strictly necessary is sought by the DNO.

  - Expert advice and support should be sought for this work if internal expertise on the process and requirements is unavailable.



- The tidal stream industry must discuss full scale build out plans with national grids to ensure the national grids can support the future scale of projects (with consideration to grid compliance requirements).

2.5 Health Safety and Environment (HSE)

- Project and technology developers need to balance their various stakeholders' requirements, including their HSE obligations. Test sites may impose various HSE requirements in contracts/project agreements and when preparing/monitoring marine operations. Good planning and transparent sharing of relevant information between the various parties are particularly important.

- Applying the general good practice approaches noted throughout this report will also assist in meeting HSE obligations, whilst the converse is often also true.

- Offshore operations are multi-faceted and challenging by nature, often involving complicated activities performed simultaneously, e.g., vessel operations, deck works with restricted space, electrical works, working at height, heavy lifting, submarine works, all of which have their own individual risk profiles. Meticulous planning is needed to ensure detailed procedures are understood by all stakeholders, including in-depth risk assessments to identify potential dangers and implement risk mitigation measures.

2.6 Local infrastructure

- Project partners need to ensure they have the relevant knowledge of local infrastructure. The lead partner or other project partners may be able to assist.

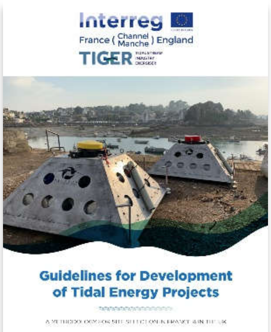
2.7 Management

- Although there are resource implications, it is important to have a balanced representation during meetings – technical, commercial, policy etc. as different viewpoints can facilitate better discussion and/or decision making.

- The scope, timeframes and budgets associated with large public-funded projects can be difficult to change, and careful stakeholder management may be needed to achieve consensus.

- Good local stakeholder management needs local staff/management.

- Site developers (whether by design or necessity) need to ensure they have a good understanding of the overall site development process and timings, either internally or from partners or subcontractors, particularly for seabed leasing and environmental consenting, site data requirements and collection, and grid connection.
    - See https://interregtiger.com/download/tiger-report-guidelines-for-development-of-tidal-energy-projects/.



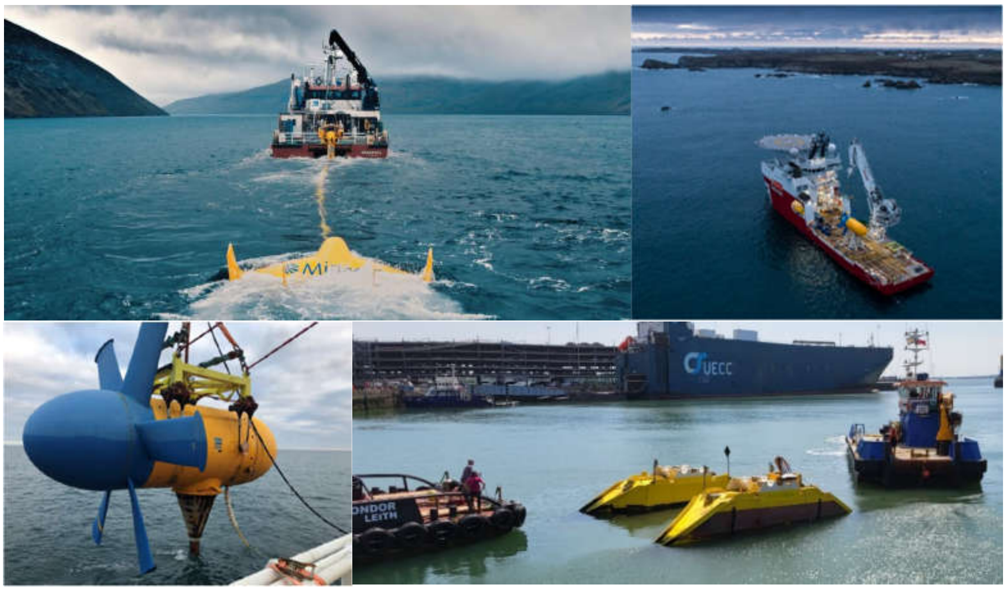
- Project funders and/or lead partners can assist through undertaking due diligence assessments of projects early in the project lifecycle and then providing follow-up project support and mentoring activities on project and technology development - which can be especially beneficial in bringing experience of multiple industry projects and so highlighting blind spots and the importance of 'knowing what you don't know'.

2.8 Marine operations (including installation, retrieval etc.)

- Robust cost estimates are needed when considering project options and/or changes, as initial cost estimates often suffer from optimism bias. Marine operations costs in particular are often significantly underestimated.

- Relevant vessel availability, cost and cost variability are all known to be key for TSE turbine deployments.
    - However, external events (in this case COVID-19 and Brexit) can change these factors even more than is generally expected. Brexit has affected the requirements for UK-flagged vessels to operate in the EU.
    - It may be beneficial to use a vessel broker to charter vessels rather than trying to procure suitable vessels independently, especially if the latter may restrict you to a single/limited number of suppliers and thus only provide access to a limited number of suitable vessels that may impose further constraints on marine operations.
    - Consider using ports/infrastructure that do not impose additional constraints on marine operations timings (e.g., a need for a certain tidal height for launch/berthing or movement into/around/out of the port).

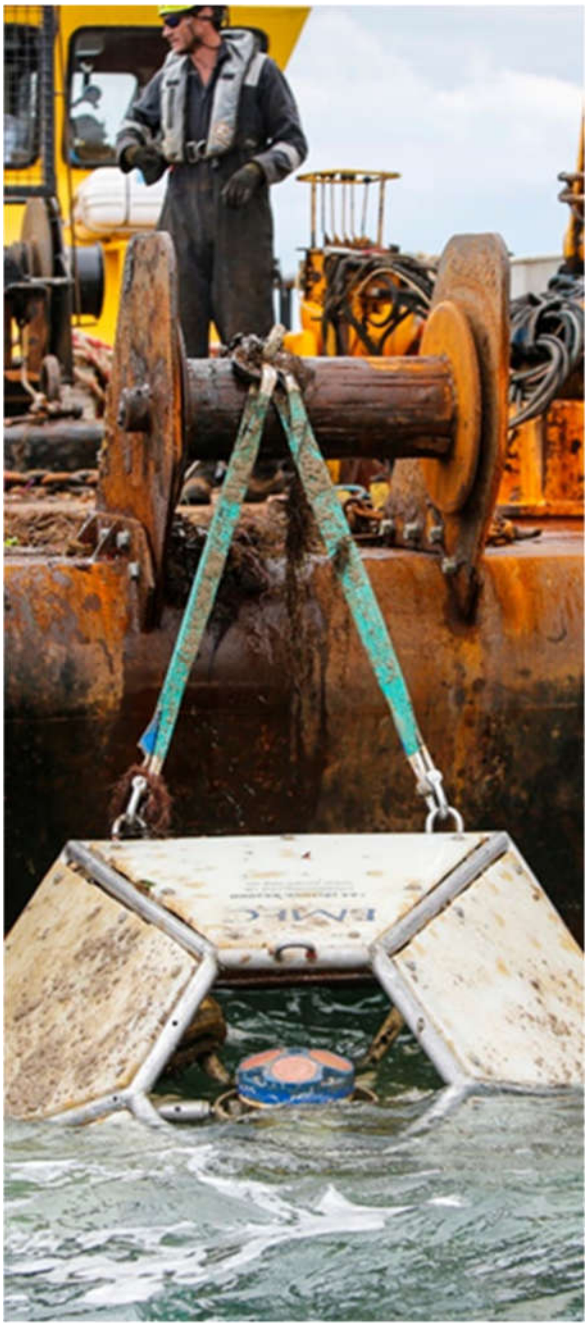
- Have a credible O&M plan with associated vessel costs, which supports the LCoE requirements of the project. DP vessels designed or modified specifically for TSE operations may be suited to smaller turbines.



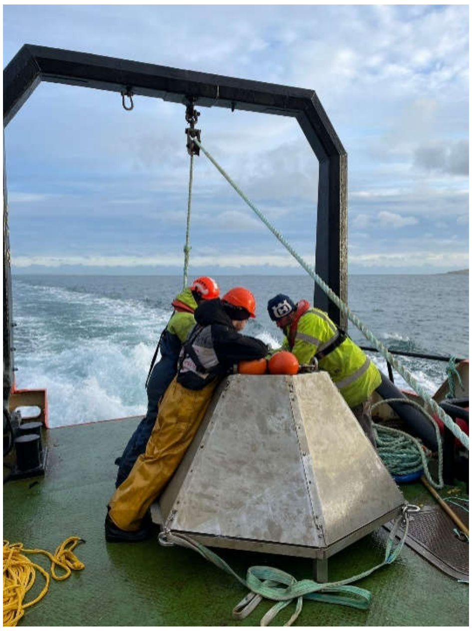
- Ensure that the skipper and crew of vessels which are undertaking marine works in tidal races have been fully briefed by their companies well in advance of departure so that there are no surprises when work starts.

- The "T1.5.3 Installation of the Sabella D10 turbine" report at: https://interregtiger.com/download/installation-of-the-sabella-turbine-d10-feedback-for-future-installations/ contains further recommendations.

- Carefully assess the preferred installation and recovery strategy for any seabed-mounted ADCP deployments, bearing in mind the local environmental conditions (tidal currents, waves, underwater visibility, etc,) and local hazards (bathymetry, trawling operations etc.).
    - Overengineer subsea test equipment, such as ADCP frames and associated equipment (canisters, anodes etc.), to be deployed in fast flowing tidal sites, and provide for a longer time subsea than anticipated.
    - If interference between two nearby ADCPs is to be avoided completely, then 100m separation may be required (for 500kHz units). ADCPs situated close together should preferably operate at different frequencies.
    - Using a USBL (ultra-short baseline - a method of underwater acoustic positioning) system during an ADCP deployment can significantly help in monitoring of the ADCP position and tilt. Also, using a vessel-mounted ADCP to monitor the current throughout the water column during operations can provide additional insights.



    - If relocating an ADCP between nearby sites to collect further data, bring it to the surface to check correct operation and alignment before relocating to the second site, even if this means an extra tide / slack is required.

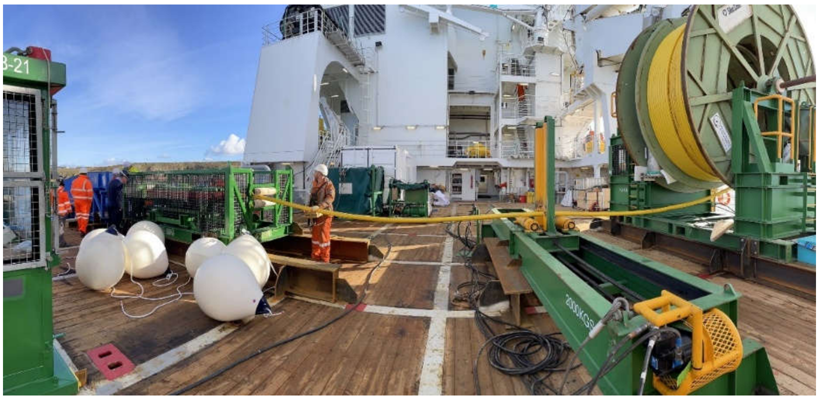


- If using acoustic release beacons/pop-up floats, then:
    - Using two is recommended to add redundancy;
    - The rope may get entangled due to a combination of:
        - Rope being waxed and sticking to itself,
        - Rope being packed too compactly,
        - Pop-up float being released before the full slack.

- See also https://interregtiger.com/download/tiger-tidal-test-procedure-reports/?wpdmdl=6239&ind=1690366406406 for further general recommendations on seabed-mounted ADCP deployments.

- If undertaking vessel-mounted ADCP works:
    - The structure holding the ADCP needs to be capable of operating in conditions beyond the maximum anticipated.
    - The vessel selection requirements need to include the capability of operating in short steep seas created by wind over the tide.
    - There are significant challenges operating in darkness in a tidal race:
        - Good seamanship is needed for the rapidly changing environment.
        - It is necessary to pilot the vessel accurately to a computer screen.

- Cable stored on a cable drum needs to be correctly tensioned and evidence of correct tensioning should be sought prior to acceptance from the supplier or storage company.



2.9 Objectives

- Lead partners should seek to understand all partners' motivations and details for their aspects of the project more clearly at the application stage.

Projects may be more successful if the project objectives and plans are more defined at the application stage than is possible in the application form (e.g., in work package execution plans), to enable a more focussed project implementation.

2.10 Operations (and reuse of legacy equipment)

- Ensure the usability of legacy equipment (technically and commercially) is understood and take appropriate action to maintain and/or replace it as necessary.

- Subsea cables may suffer degradation when abandoned (unused) underwater for (even relatively short) periods of time.

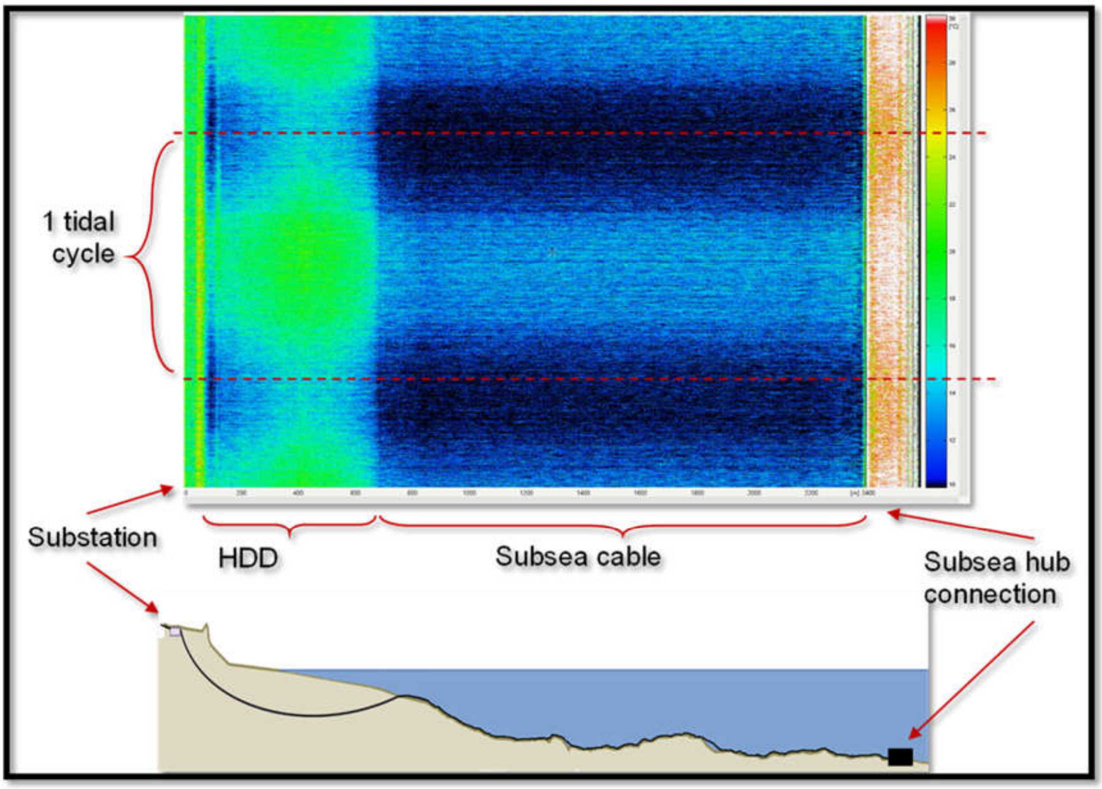
- Cable testing is a complex task requiring specialist equipment with knowledgeable operators, and may need access to both ends of the cable. Expert advice and support should be sought to assist with decisions if internal expertise unavailable.

- Reuse and/or re-purposing of existing equipment is often more difficult than first envisaged. Quantifying the condition of existing subsea assets (foundation structures, cables, connectors, mooring equipment etc.) using standard equipment such as ROVs is difficult and a conservative approach to potential re-use is needed unless state-of-the-art subsea surveying techniques are used (see below).

- State-of-the-art subsea techniques are effective to survey existing infrastructure.

- Retrofit wet-mate system integration is possible on existing infrastructure, when state-of-the-art survey techniques have been used to inform design of retrofit.

- Integration of a distributed temperature sensing (DTS) system on an existing subsea cable is relatively simple.
    - The key requirement is the availability of spare fibres.
    - DTS data is relatively small in quantity, but still needs consideration at the time of purchase to ensure sufficient data storage capacity is present.
    - An extensive library of design and construction information is required to enable interpretation of the DTS data to identify specifics about the operating environments.



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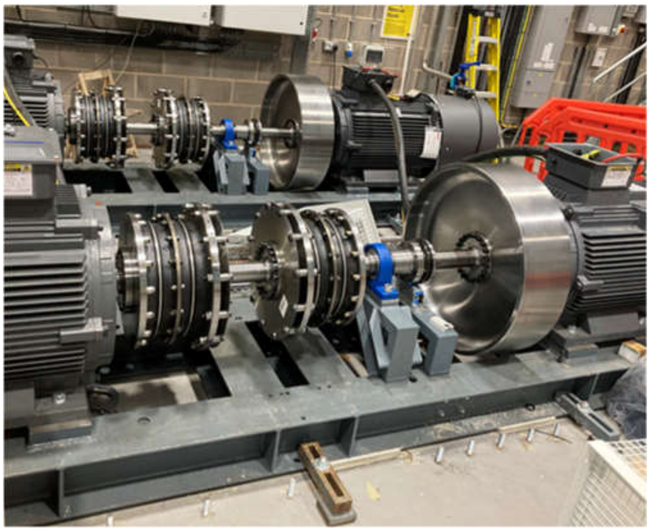
    - The DTS system installed within TIGER has shown that the maximum temperature in an export cable to date is significantly below the design temperature. This is primarily driven by theoretical values for the operating environments (as well as the limited operating period of the DTS system to date) and conservative design standards for subsea cables (e.g., based on continuous maximum output rather than the predictably variable output from tidal turbines). It may be economic to derate the turbines in the event of extreme environmental conditions and work to lower design temperatures.

2.11 Procurement and contracting (including manufacturing/fabrication)

- Public funding body's and/or lead project partner's ability to guide project partners on public procurement requirements is invaluable. The importance of project partners fully understanding, and ensuring compliance with, the public procurement requirements (and other good procurement practices) cannot be overstated. These include:
    - Open, transparent, equal treatment for all suppliers.
    - No shortcuts in procurement activities.
    - Monitor all purchases, don't push any through as business-as-usual.
    - Administration must be compliant with stated processes:
        - It may be time consuming/resource heavy.
        - Capture comprehensive evaluation notes.
        - No changes to evaluation criteria.
        - Conflict of Interest / Confidentiality forms signed.
        - Single tender justification must be sound.

- The current demands from the TSE industry are small in comparison to the demands from other sectors (e.g., offshore wind), leading to limited leverage.
    - Early engagement with several potential suppliers is recommended to mitigate programme issues, especially for electrical equipment such as wet-mates and cables.



    - Management and minimisation of interfaces and effective supply chain integration needs balancing with competing cost/stakeholder pressures. Best practice interface management techniques can help mitigate risks.
    - The desired equipment warranties may be difficult to obtain, meaning that robust acceptance testing at all stages of the project becomes even more important (witnessed by appropriately qualified parties).

- TIGER delivered a series of 6 themed supply chain webinars which looked into different areas of challenge for the TSE sector. Recordings can be found by filtering for "supply chain webinars" at: https://interregtiger.com/resources/.
    - Delivered together with technology developers, these webinars attracted over 1,000 individual participants and over 7,000 views online.

    - This is clear evidence of significant interest from the supply chain in becoming involved in the TSE sector.

- There remains some work to be done collectively by the tidal stream industry to improve the credibility of the industry, as the supply chain has seen a number of false dawns in the last decade. The business case for tidal stream in Europe is strong enough to incentivise the supply chain providing the political and commercial industry strategy is well communicated.

2.12 Programme & budget

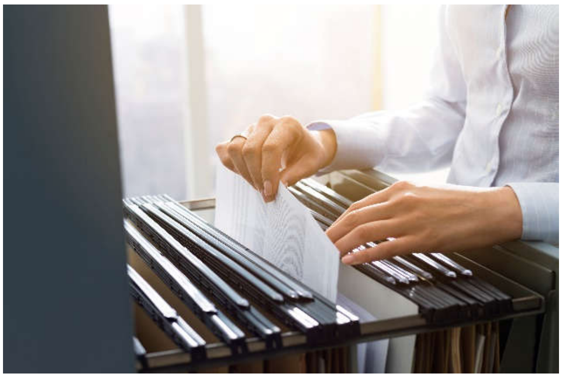
- Lead partners should set out their expectations for programme and budget forecast updates more clearly at the application stage, including the use of key milestones. Lead partners can also set out template programmes or assist project partners with programming activities during the project.

Project partners should ensure they create and maintain a well-developed project programme and budget which can be used to actively manage the project.

Having a well-developed project programme and setting deadlines helps ensure activities that may become critical path do not.

- Even well-planned and well-managed programmes and budgets, with reasonable levels of contingency, can be affected by major external events (e.g., Brexit and COVID-19). Although best practice programme and budgeting can assist with identifying issues earlier than otherwise, major changes to project objectives or funding requirements may still be required.

2.13 Programme

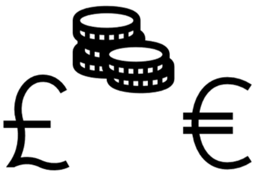


- There is a need for all project partners to understand the significant level of administrative requirements when planning for and resourcing large and complex EU funded projects.

- Make robust estimates of the time required for design work and its iterative nature together with internal approvals, and allow sufficient contingency to mitigate uncertainties.

- Re-programming approaches should balance the desire to meet the existing programme with the better control that is achieved from a more realistic outlook. In particular, re-programming should focus on estimating the realistic 'time to complete' rather than basing this off a 'percentage complete' approach.

2.14 Resources (funding)



- Project objectives and plans need to be well developed at the application stage to ensure robust budgeting. Opportunities may be needed to allow suitable project adjustments and identifying such opportunities as early as possible can help significantly.

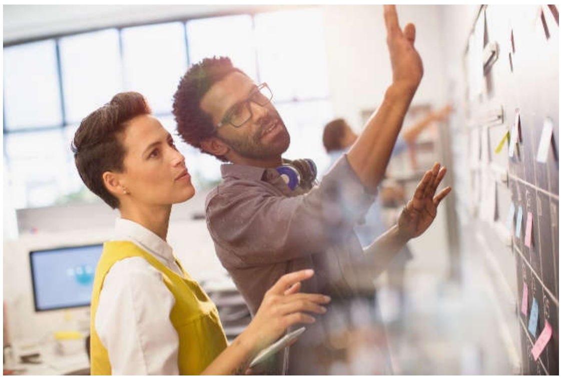
- Project developers need to be aware that grant funding, especially for large and/or first-of-a-kind projects/grants, can take several years to be fully negotiated and approved. Funders should work to streamline the process to reduce the timescale, and be clear up-front about the timescale and other requirements.

- Ensure match funding is in place before starting a project; have an alternative project plan if funding does not materialise, which can be implemented in sufficient time to recover situation.

- Raising further investment in TSE technology and projects remains challenging, not helped by the more recent uncertainties due to COVID-19 and Brexit. The lack of clarity around support mechanisms in UK/France has been a major barrier, which was partially resolved for the UK only in November 2021.

2.15 Resources (people)

- The resources required need to be robustly estimated.
    - Even just the Project Management on grant-funded projects can be significant.
    - Project partners need to ensure sufficient resources and/or mitigations for cross-project delays if implementing multiple projects at similar times.
    - A more focussed, better planned and better resourced, approach may ultimately be more successful overall.



- Ensure project teams have access to the necessary project management and technical skills and experience to be able to effectively identify project requirements and to manage partners and subcontractors.

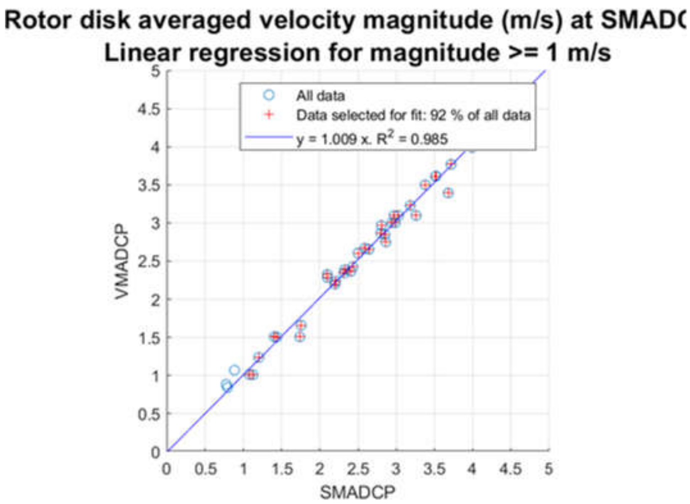
- To mitigate staff changes in organisations, good record keeping and information handover are important to ensure smooth and delay free transitions.

2.16 Site data and site development

- Site developers need to ensure they have a good understanding of the overall site development process and timings, either internally or from partners or subcontractors, particularly for seabed leasing and environmental consenting, site data requirements and collection, and grid connection. See:
    - https://interregtiger.com/download/tiger-report-guidelines-for-development-of-tidal-energy-projects/.
    - https://interregtiger.com/download/tiger-data-collection-and-survey-best-practice-report-2022/.
    - and T1.4.5 “Lessons learned from developing tidal sites” for a case study example: https://interregtiger.com/download/tiger-lessons-learned-from-developing-tidal-sites-in-the-uk-channel/.

- Accurate yield estimations are essential in ensuring a reliable cost model for the project. Whilst numerical models may give a good estimation of flow distribution at a site, especially after calibration and validation activities, the importance of yield estimations within a project cost model requires the best possible accuracy of yield estimations, hence the potential need for an ADCP campaign at the project turbine location(s) which is then extrapolated for the project timescale.

- Site developers should be familiar with the IEC Technical Specification for Tidal Energy Resource Assessment and Characterisation (IEC TS 62600-201) as well as related industry measurement and modelling techniques, and the IEC Technical Specification for Electricity producing tidal energy converters – Power performance assessment (IEC TS 62600-200).
- The TIGER T1.6.6 – MeyGen 2022 Field Work Analysis report outlines the development of a novel resource assessment approach (using vessel-mounted ADCP measurements in combination with concurrent seabed-mounted ADCP measurements) that is expected to be included in the second edition of IEC TS 62600-201. https://interregtiger.com/download/technical-report-on-high-fidelity-flow-data-field-work-and-analysis-including-vessel-based-flow-measurements-and-turbulence-measurements-at-meygen/.



- The TIGER T1.7.3 reports (1-3) provide a gap analysis of the first edition of IEC TS62600-200 and recommendations for future editions (and specifically for floating and non-conventional tidal turbines). Report 4 outlines lessons learnt and recommendations for ADCP deployments, building on those in Section 2.8. https://interregtiger.com/download/tiger-tidal-test-procedure-reports/.

- The TIGER T1.6.6 – MeyGen 2022 Field Work Analysis report also outlines the differences in turbulence measurements obtained when using a 5-beam ADCP rather than a 4-beam ADCP: https://interregtiger.com/download/technical-report-on-high-fidelity-flow-data-field-work-and-analysis-including-vessel-based-flow-measurements-and-turbulence-measurements-at-meygen/.
  - The impact of over-reporting turbulence is detailed in the associated report: https://interregtiger.com/download/summary-report-on-the-

impact-of-high-fidelity-flow-data-field-work-and-analysis-on-lcoe-of-normandie-hydroliennes-tidal-project/.

- The timescales and budget needed to agree access to data previously gathered by others can be much more significant than expected. As the seller and the buyer often have differing opinions on the value of the previous data, it may be prudent to plan to gather new data rather than rely on purchasing previous data.

2.17 Standards, guidelines and certification

- In general, project and technology developers need a better understanding of the applicable standards, technical specifications and guidelines that have been developed for the benefit of the TSE industry (and other industries).
    - https://iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1316,25 details the scope of IEC TC 114, which is to prepare international standards for marine energy conversion systems.
    - https://www.afnor.org/ hosts the French national committee for IEC TC 114.
    - The British Standards Institution (BSI) hosts the UK national committee for IEC TC 114, currently acts as secretariat, and provides details of the (17) currently published IEC documents at: https://standardsdevelopment.bsigroup.com/committees/50176875#published, whilst updates and documents under development are at: https://standardsdevelopment.bsigroup.com/committees/50176875#in-progress.
    - The major certification bodies active in the market (e.g., DNV-GL, Lloyds Register and Bureau Veritas etc.) have also all published standards, specifications and guidelines which are used within the TSE sector, especially when technology or project developers are seeking certification, and the certification bodies and design/engineering consultants can provide guidance on applicable documents.
    - Within TIGER, both IEC TS 62600-201 and IEC TS 62600-200 were reviewed and recommendations provided for future editions (Section 2.16).
    - As with all testing, it is important that the various data uncertainties and equipment calibration procedures are reviewed (preferably with any third-party assessor) prior to power performance assessment tests being undertaken. The TIGER T1.2.5 report outlines the application of IEC TS62600-200 to a full-scale turbine deployment: https://interregtiger.com/download/paimpol-brehat-testing-power-curve-accreditation-and-data-sharing-reporting/.

3 Conclusions

- The introduction to Section 2 highlights key TIGER (and other) resources.
- Undertaking large, collaborative, publicly funded projects requires significant planning by all parties, and all parties should be clear on their commitments and how they will be achieved - as well as the projects' requirements and limitations.
- Lead partners should set out their expectations for programme and budget forecast updates clearly at the application stage, including the use of key milestones. Lead partners can also set out template programmes or assist project partners with programming activities before and during the project.
- The importance of project partners fully understanding, and ensuring compliance with, the public procurement requirements (and other good procurement practices) cannot be overstated (see Section 2.11).
- Projects may be more successful if the project objectives and plans are more defined at application stage than is possible in the application form (e.g., in work package execution plans), to enable a more focussed project implementation.
- There can be a significant period of time between a project application and funding award leading to project implementation. A short review at the project kick-off stage can assess whether project content remains 'current' or whether the project should be re-baselined if there have been significant approval delays.
- Site developers need to ensure they have a good understanding of the overall site development process and timings, either internally or from partners or subcontractors, particularly for seabed leasing and environmental consenting, site data requirements and collection, and grid connection - particularly where regulators and/or site developers have had limited experience of similar projects. See Section 2.16 for relevant TIGER guides and case studies.
- Project funders and/or lead partners should undertake due diligence assessments of projects early in the project lifecycle and then provide follow-up project support/mentoring activities on project and technology development.
- Rigid funding criteria makes supporting dynamic project plans difficult but early and continuous assessment of possible issues can provide sufficient visibility to allow good change management.
- All project plans should be risk assessed or stress tested regularly.
- Influences outside a partner's control can have a significant impact.
- Do not be over-optimistic when developing and committing to project programmes (even if 'fast track' options exist) and ensure sufficient contingencies are available for when 'best case' scenarios fail to occur.

- Re-programming should focus on estimating the realistic 'time to complete' rather than basing this off a 'percentage complete' approach.
- Keep subsystem design options open whilst significantly different concepts (especially those with significant impacts on/from other subsystems) are being explored. Explore challenging design options in parallel, as concepts that often appear simple in the early stage of design are later found to become more complex/costly/heavier with consequential knock-on impacts.
- The complexities associated with grid-connecting tidal arrays need due attention at the relevant points in the design process. Connecting arrays is significantly more complex than connecting single turbines and needs a different approach.
- Design of a pilot project needs to consider (later) build out of arrays. Turbines are designed for a c. 20-year life and are very difficult to move once deployed.
- The current demands from the TSE industry are small in comparison to the demands from other sectors (e.g., offshore wind), leading to limited leverage. The desired equipment warranties may be difficult to obtain, meaning that robust acceptance testing at all stages of the project becomes even more important (witnessed by appropriately qualified parties).
- Carefully assess the preferred installation and recovery strategy for any seabed-mounted ADCP deployments, bearing in mind the local environmental conditions (tidal currents, waves, underwater visibility, etc,) and local hazards (bathymetry, trawling operations etc.).
- State-of-the-art subsea techniques are effective to survey existing infrastructure.
- The maximum temperature in an export cable may be significantly below the design temperature when using conservative design standards for subsea cables based on continuous maximum output rather than the predictably variable output from tidal turbines. It may be economic to derate the turbines in the event of extreme environmental conditions and use lower design temperatures.
- In general, project and technology developers need a better understanding of the applicable standards, technical specifications and guidelines that have been developed for the benefit of the TSE industry (and other industries).